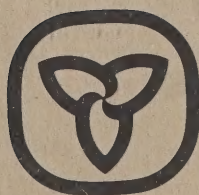
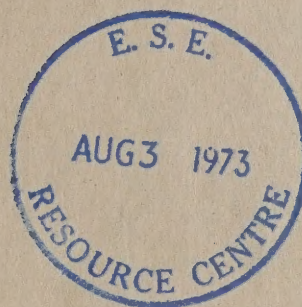


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Pesticides and the Environment



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CONTENTS

	Page
Introduction	1
What's a Pesticide?	3
Pesticide Residues in Humans	4
Causes of Pesticide Contamination	7
Pesticide Residues in Soil and Vegetation	8
Pesticide Residues in Water and Aquatic Life	9
Pesticide Residues in Birds	12
Pesticide Residues in the Atmosphere	13
Pest Control Research	14
Government Supervision of Pesticides	16
Safe Pesticide Use	17

PESTICIDES AND THE ENVIRONMENT ✓

Introduction

Pollution of the environment by pesticides is a serious problem. It can only be overcome through proper use of these potentially dangerous chemicals by homeowners, farmers and exterminators. Good user practices combined with Ontario's pesticides laws and careful evaluation of new chemicals and methods of use can turn what could otherwise be a bleak and ugly environmental future into one that's green and alive.

There is no immediate threat to human life from present pesticide contamination of man's food and water. However, cases of illness and even death have been reported as a result of misuse, improper storage, handling and transportation of these chemicals. Wildlife and aquatic life are more sensitive to the effect of pesticides which, even in relatively small quantities, can interfere with their reproductive processes or sometimes cause death.

Some scientists claim that pesticides can be a threat to plankton, the biological basis of the photosynthesis process which is the source of about 70 % of the world's oxygen.



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At this point you may seriously question the value of pesticides, considering the damage they can do if misused. However, without pesticides man's food supply would be greatly decreased in both quantity and quality. Also, the threat to public health from the uncontrolled spread of vector-borne diseases would be as serious, or even more so, as the problem of pesticide contamination of the environment.

Consider the losses to insects in agriculture, even when pesticides are used. In North America today there are thousands of major species of insects that infest plants and crops, causing an annual loss of some \$5 billion. In Canada alone, the losses suffered in the livestock industries from insect damage are estimated to be about \$100 million a year. In 1946, the dawn of the era of new organic pesticides, the entire tomato crop of Eastern Canada was threatened by blight (a fungus disease). In 1962, in another case, the European corn borer insect caused a loss of 88 million bushels of corn.

Now, consider the losses that would be suffered if there were no pesticides. According to one expert, Ontario would lose 40 - 80 % of its apple production within two to three years as a result of the damage caused by just one insect species -- the codling moth. Without herbicides, farmers would lose up to half of their entire crop production to the rapid spreading and choking action of weeds.

The fact that we have not had a major outbreak of vector (organism) - borne disease in Canada for some time is not just the result of the development of cures for these afflictions. Much of the

credit goes to pesticides for eliminating the problem at its source -- the carriers. There is no doubt that the Black Death (bubonic plague) could have been kept under control if rodenticides had been available in Europe and Asia in the fourteenth century.

Obviously it is not just a matter of banning all pesticides to save the environment, as one does not necessarily lead to the other. Rather, we need to make the most efficient and safe use of pesticides to prevent their adverse effects on our environment.

What's a Pesticide?

Just what do we mean by the term "pesticide"? The definition given in the Ontario Pesticides Act and Regulations is "any substance used for the destruction or control of insects, vermin, birds, rodents or other pests and fungi or vegetation including micro-biological agents".

The term "pesticide" denotes a general category of chemicals which covers the more specific categories of insecticides (chemicals that kill insects), herbicides (kill weeds), fungicides (kill fungus), rodenticides (kill rats and mice), miticides (kill mites), nematocides (kill nematodes), and so on.

In terms of chemical structure, they are divided into main groups: inorganics and organics. The inorganics are the older pesticides, such as the arsenicals and plant-derived materials (pyrethrum and derris dust). The modern organics of the post-1940s pesticide era are of more complicated chemical structure and include the chlorinated

hydrocarbon insecticides, the organic phosphorus insecticides, the carbamates and similar types.

In the home, pesticides occur most commonly as aerosol sprays and moth balls (paradichlorobenzene), and as liquids in larger quantities for garden and extermination use. On the farm, pesticides are purchased in bulk for large-scale application by ground equipment and aircraft.

There are more than 300 organic pesticide chemicals in general use in Canada today, marketed in more than 15,000 formulations. The Canadian agricultural chemical industry sells about \$50 million of pesticides a year.

Misuse of these chemicals produces excessive amounts of pesticide residues in our environment. The improper use of a pesticide would be using one that is more toxic than necessary, or using more of a pesticide than is necessary, which could lead to contamination of humans, animals, their food and feed, and of air, soil and water. If we are to save our environment, we must always use the correct chemical and method of application. Directions on container labels must always be followed.

Pesticide Residues in Humans ✓

Pesticide contamination of humans is mainly the result of eating foods containing pesticide residues (ingestion), spilling chemicals on skin (skin contact), and breathing fumes when using the material (inhalation). This poses no immediate threat to human life or health. In

fact, over the past 25 years, deaths from pesticide poisoning in the United States have averaged one a year for every million of population. (These deaths were caused by high occupational exposure, accidental ingestion and suicide attempts, not by general contamination).

What causes health officials some concern is the long-term or chronic effect on man of pesticides in our environment. This has yet to be determined. In North America, the level of DDT (dichloro-diphenyl-trichloroethane) -- a member of the chlorinated hydrocarbon group -- stored in human fat has reached a peak level of about 12 parts per million. We seem to be able to eliminate from our bodies any further DDT residues ingested. (One part per million, or ppm, is the equivalent of one pound of pesticide in one million gallons of water).

DDT is stored in fat because it is a fat soluble and, as an organic chemical, it has a great ^{attraction} affinity for other organic compounds. The same principle applies to fat in milk.

Tolerance levels of pesticides in our food do not necessarily indicate the point at which harm can be done to the consumer. They are the maximum levels at which no effects can be seen in test animals, usually white rats, receiving this dosage. Just to be on the safe side, these levels are often adjusted to provide for a safety factor of a hundred or more.

In the United States, for example, the Food and Drug Administration annually conducts testing of 25,000 samples of various food commodities for residues of pesticides. From 1963 to 1967, the tests uncovered residues exceeding tolerance levels or administrative guide-

lines in only three percent of the cases. It was found that the majority of samples contained very low levels of these insecticides -- 75% of individual residues were below 0.11 ppm.

It is because the more persistent pesticide residues have the ability to travel great distances in air, water and transported food that human contamination by pesticides has reached people living in the remote, primitive subarctic regions of Alaska. A study of these people revealed a mean concentration of 1.4 ppm DDT and 3.8 ppm DDE (a derivative of DDT) in their body fat. Since neither of these chemicals was found in native foods and there is no record of DDT ever being used in that part of the world, it was assumed that the source was foods imported to the area. Drift of pesticide residues was blamed for the small quantities of DDT found in fat samples from polar bears living near the North Pole.

Human deaths from pesticides in North America, as previously mentioned, are rare and usually occur when these chemicals are carelessly handled. Cases of mass deaths from such poisoning are virtually limited to less developed countries. There, the lower level of education produces a lack of understanding of proper handling of these materials.

This is exemplified by a report of 75 deaths and about 500 illnesses from parathion contamination of bread in a town in Columbia, South America, in November 1967. Bottles of the insecticide - in what can only be termed a flagrant example of negligence - were shipped in the same truck as the flour from which the bread was to be made. One

of the bottles broke and the liquid spilled over the flour.

A similar incident happened in Turkey. Seed grain treated with the insecticide benzene hexachloride (BHC) was eaten instead of planted; there were 330 deaths and 3,000 illnesses.

Causes of Pesticide Contamination

General contamination of the environment can be the result of intentional or unintentional (direct or indirect) application of pesticides. It is intentionally applied to animals, crops, soil and water -- in the latter case for the control of mosquitoes, water weeds and trash fish. Other examples of direct application are household and garden use and the mothproofing of clothing and household fabrics.

Virtually all living organisms are affected by indirect contamination. This is caused by pesticide drift in the atmosphere followed by rain-out or snow-out, mishandled pesticide operations, improper dumping and cleaning of spray tanks, dumping of chemicals into the sewage system, industrial wastes of pesticide manufacturers and mothproofing industries using pesticides, dumping of food products containing residues exceeding tolerance levels, animal dipping vats, and decaying plant and animal tissue.

Once in the environment, these chemicals are broken down into simpler and possibly safer substances, according to individual characteristics and surrounding conditions. Generally speaking, the organic pesticides either vaporize (escape as mist), oxidize (combine with oxygen in air or from other compounds), hydrolize (form an acidic or

basic solution), or metabolize (break down into simpler substances when attacked by organisms). Since there is a wide variation in decomposition rates (for example, chlorinated hydrocarbon insecticides as a rule are more persistent than organic phosphorus ones), the hazard to man varies. Some pesticides can be tolerated in relatively large amounts, while others cannot. Some persist for years, others last for a few weeks or months.

As the newer organic pesticides are subject to decomposition by physical and biological means, they are generally less persistent than some inorganic pesticides, mainly the arsenicals.

Pesticide Residues in Soil and Vegetation ✓

The persistence of pesticides in soil is determined by a number of factors. Insecticides and herbicides persist longer in soil high in organic matter, because they are attracted to and are not readily released from this matter. Moisture in the soil greatly increases the evaporation and breakdown of certain pesticides. Some micro-organisms in the soil can break down pesticides into other chemicals.

The type and the amount of material applied, formulation, dosage and number of applications per season will have a determining effect on the level of contamination and the pesticides residue in the environment.

Weather factors, such as increased temperatures, light, humidity, air movement and rain, can speed up the breakdown of the organic pesticides and thus reduce their persistence.

Plants to which pesticides are directly or indirectly applied play a part in residue concentration and persistence. Cover crops, such as alfalfa, reduce the effect of wind that stirs up pesticide- contaminated soil particles. Persistence is also determined by a plant's shape, density of foliage, protection of edible portions by leaves, enzyme systems, and surface fuzz or waxiness. Generally, pesticides stored in plants are diluted as the plants grow.

During and after harvest, pesticides remaining on plants can be further reduced by trimming and stripping operations on edible commodities, and washing and cooking in the home will remove a great percentage of the residue.

There has been only one case in Canada where soil contamination was of a dangerously significant level, according to the Federal Food and Drug Directorate. This occurred in the valley of Grand Forks in British Columbia about four years ago.

In fact, there are some claims that pesticides have been applied to only five percent of the world's arable lands.

Pesticide Residues in Water and Aquatic Life ✓

Water and aquatic life are particularly susceptible to pesticide contamination. Surface and ground waters are affected by direct or indirect ground and aerial spraying, runoff from treated areas, leaching, waste discharge from pesticide manufacturers, and chemical misuse.

Contamination of water can be either of a chronic or acute nature. Chronic contamination usually occurs at levels of one part per billion or lower following gradual runoff and waste discharge. Acute contamination is of a higher, short-term nature and results from direct application to water, runoff from land following heavy rains, or accidents during pesticide application.

The dangers of biological magnification - the build-up of pesticide residues in the succeeding higher levels of a food chain - is at its greatest in water. For example, DDT was applied in 1949, 1954 and 1957 to control gnats in the waters of Clear Lake, California. The dosage rate was 14 parts per billion. Later, it was found that plankton built up a residue level of 5 ppm. By eating the plankton, the fish concentrated the pesticide in their fat at levels of from 40 to 2,500 ppm. This was sufficient to kill western grebes (a species of waterfowl) feeding on the fish.

There are other ways for pesticides to build up in aquatic life. Large amounts of water are strained through the gills of fish. This filters out particles containing pesticides. In one experiment (Premdas and Anderson) Atlantic salmon, exposed to water containing 1 ppm of DDT for five minutes, concentrated the insecticide at a level of 1.56 ppm in their spleens and livers. Those left in the water for an hour reached levels of 31 ppm.

Oysters are just as efficient in removing such chemicals from water. One case was reported where a seven-day exposure to water containing 0.01 ppm of DDT resulted in stored levels reaching as high

as 151 ppm.

Pesticide contamination of water caused by misuse is taking its toll in the fishing industry. Over the past four years the U.S. government has withdrawn from the market hundreds of thousands of coho salmon caught in Lake Michigan -- the most heavily contaminated of the Great Lakes. The fish contained more than the maximum 5 ppm of DDT allowed for fish under U.S. standards.

Trout in Ontario lakes have also built up high levels of DDT. Five Lake Simcoe trout examined in 1967 carried DDT levels of from 12.55 to 18.44 ppm. In Lake Muskoka, DDT levels in trout averaged 29.7 ppm (and in whitefish 13.7 ppm). According to the Ontario Lands and Forests Department, levels of 3 ppm of DDT can disturb lake trout reproduction. This department has for some time been carrying out restocking programs to maintain the population of lake trout.

Thousands of trout were killed in a four-mile section of the Sable River in Prince Edward Island when dithane M-45 was carelessly used. Investigation showed that a potato sprayer machine loading water from the river had spilled back some water containing the dithane M-45. Had the machine been equipped with a proper device to prevent backflow, this would have been prevented. Also, empty chemical bags were found in the water. Officials say it may take several years before the river regains its full, normal trout production.

The insecticide, Endosulfan -- which has been used without major incident in Canada for the past 12 years -- was recently

accidentally used in Germany to such an extent that hundreds of thousands of Rhine River fish were killed.

Pesticide Residues in Birds

Waterfowl, such as the western grebe previously mentioned, suffer the effects of high levels of pesticide contamination by feeding on already contaminated fish. A study reported by the U.S. Department of Health showed that 71% of waterfowl and their eggs from selected areas of Canada and the United States, tested from 1961 to 1963, contained residues of chlorinated hydrocarbon insecticides.

Upland game and other birds acquire pesticides by other means. For example, biological tests of pheasants and Hungarian partridges in Alberta's upland game areas found them to be contaminated with mercury from treated seeds they consumed from farm areas. They also contained insecticide residues.

One classic case of pesticide misuse resulting in the build-up of lethal concentrations of residues occurred at the University of Michigan in the mid-1950s. DDT was sprayed on campus trees to kill bark beetles that were spreading Dutch elm disease. The beetles began to die off, but so did a great many robins. Looking into the tragedy, researchers found that the robins had eaten earthworms which, in turn, had fed on DDT-covered leaves that fell to the ground. By eating these worms, the robins accumulated lethal concentrations of DDT in their systems.

Pesticides stored by birds in fat may have a delayed but just as deadly effect. During periods of stress or reduced feeding --

as in migration -- this fat is used to sustain life. As the fat is metabolized and circulated through the digestive system, so also is any deadly level of stored pesticides that otherwise would have had a lesser effect.

Some species of Canadian birds are in danger of becoming extinct because of the effects of pesticides -- and also as a result of the destruction of their habitat by man. According to the Federal Department of Northern Affairs and Rural Development, seven species of birds have seriously declined in number over the past 20 years. These are the greater prairie chicken, peregrine falcon, prairie falcon, pigeon hawk, Swainson's hawk, bald eagle and gyrfalcon.

Another effect of DDT which contributes toward the decline of bird populations is the fact that this insecticide upsets their calcium production. As a result birds may lay eggs too thin-shelled to be hatched.

Pesticide Residues in the Atmosphere

Pesticides in air are an original pollution burden, unlike more recognized forms of air contamination that add to chemicals already in the air. Pesticides enter the air through the escape of fine droplets of chemicals during ground or aerial spraying; evaporation of residues, stock materials or wastes; the stirring of pesticide-containing soil particles by wind; smoke from the manufacturing process; burning supposedly empty containers; warehouse fires.

In some cases -- mainly chlorinated hydrocarbon chemicals --

conditions may be such that as much as half of the applied material is unaccounted for after an area has been treated. Much of the missing amount is carried as fine particles or droplets to distant areas.

The distance pesticide residues drift in air depends on the speed and direction of the wind, the topography over which the pesticide is carried, and weather phenomena such as inversion layers that have a containing effect on the floating chemicals.

Great distances can be covered if the required conditions come into play. Pesticides in air can travel from one country to another and even one continent to the next. They can also reach great heights. The source of 0.3 parts per billion of DDT found in ice laid down on Washington state's Mt. Olympus in 1964 is suspected to be rain-out or snow-out of DDT in air.

The persistence of pesticides in air is related to both weather conditions and the nature of the chemicals. Rain or snow serves to clean the air of all particulate matter, including pesticides. Oxidation in air is more rapid, since more of the chemical's surface is exposed. Also, if spray equipment is properly adjusted and the formulation correctly mixed, spray droplets will be large enough to fall mainly within the area being treated.

Pest Control Research

Even though the advantages of properly used pesticides clearly outweigh any disadvantages, the people involved in this field are continuously striving for improvements. Research scientists, government

agencies and pesticides manufacturers are presently searching for even safer chemicals and non-chemical methods of pest control.

There are some promising although not yet fully practical non-chemical methods. The sterile male technique involves the release of huge amounts of male insects incapable of propagating the species. Eggs laid by female insects which mate with these males are unfertilized and do not produce offspring. In this way, the species is largely reduced or effectively eliminated.

Predatory insects -- those that feed on crop-destroying insects and not the crops -- have been used successfully in some instances. Although the first use of this method was in 1880 when Australian insects were imported to prey on insects threatening California citrus trees, it has not yet proved to be an effective control in all situations.

Viruses deadly to insects but harmless to man are now being developed and will soon be in general use. One such virus was successfully field tested against tobacco cutworm in 1969 by the Belleville (Ontario) Research Institute, in co-operation with the Canada Agricultural Research Station at Delhi, Ontario.

Botanists are also contributing to this research drive. Their efforts are directed toward finding new plant species resistant to insects and other pests. They are even trying to find a plant species that would give off chemicals to check the growth of weeds.

National governments seek to prevent new insect species

from entering their respective countries and establishing themselves in new environments. The public can help in this regard by observing border quarantines barring the entry of plants, animals and other pest carriers. In an extension of this method, some governments help other countries to eliminate their pests. This is both an act of generosity and a means of preventing these species from crossing borders into other countries.

Massive but carefully controlled campaigns against various species of pests have been mounted to effectively eradicate the problem in a specific area. Such campaigns may combine the use of present-day chemicals with some of the more promising new techniques.

Insects, in some ways, determine the direction taken by research in the development of new chemicals. They are able to develop resistance to many chemicals within a few generations, thus forcing the development of new insecticides. Since 1951 more than 70 species of insects have developed resistance of some kind to many organic insecticides.

Government Supervision of Pesticides

Whenever monitoring programs and scientific research indicate that certain pesticides or their methods of use are posing a significant problem in our environment, the government of Ontario introduces the necessary restrictions or bans. A case in point are the chlorinated hydrocarbon insecticides, DDT, aldrin, dieldrin and heptachlor, the use of which has been banned in the Province since January 1, 1970.

Recommendations in this field are made to the provincial government by the Pesticides Advisory Board, a group of experts from the agricultural, chemical, pest control and extermination industries. Adopted rulings -- which become amendments to the Pesticides Act and Regulations -- are enforced by the Pesticides Control Branch of the Department of the Environment. The Service advises homeowners and licensed applicators on the proper use of chemical pesticides. It ensures public safety by licensing and supervising commercial applicators.

Safe Pesticide Use

Homeowners, farmers and exterminators can all contribute to a reduction in the amount and toxicity of pesticide residues in the environment by following the proper rules.

The least toxic material that will do the job should be used - and in the smallest amount that can be effective. The proper chemicals should be chosen and, if sufficient quantities are being used, synergists or additive chemicals can be used to increase effectiveness without increasing the dosage. Pesticide chemicals themselves should not be mixed together.

The following precautions should be taken:

1. Read the pesticide container label every time the chemical is used
2. Do not use household containers as measuring devices, or spray near them or near food
3. Do not smoke or eat when applying pesticides
4. Keep spray away from pets and their dishes

5. Keep flammable chemicals away from heat or flames
6. Wear protective clothing if using large or toxic amounts of pesticides
7. Spray in the same direction the wind is blowing during out-of-doors operations
8. Store pesticides in their tightly closed original containers under lock and key and away from food, medicines, utensils and curious children
9. Do not save empty containers, but dispose of them in a way they will not contaminate the environment
10. Wash clothing and skin thoroughly if chemicals are spilled on the body
11. Take a shower or bath and change clothing after using relatively large amounts of pesticides.

We can all safely enjoy the benefits that the proper use of pesticides offer us. By following government pesticide laws and recommendations, we will maintain a bountiful agricultural production and a high public health standard, while at the same time keeping our environment clean and alive. If we are careless, or abuse the good inherent in pesticides, we will condemn ourselves to a continuously declining quality of life.

This publication was prepared by J.G. Kurys, Education Officer, Pesticides Control Service, Ministry of the Environment.

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